Proceedings of the Nutrition Society (2015), **74**, 139–148 doi:10.1017/S0029665114001505
 First published online 16 October 2014

The Nutrition Society Irish Section Meeting was held at the University of Ulster, Coleraine on 18–20 June 2014

Conference on 'Changing dietary behaviour: physiology through to practice' Symposium 3: Novel methods for motivating dietary change

Digital and social media opportunities for dietary behaviour change

Aileen F. McGloin* and Sara Eslami
Safefood, Block B, Abbey Court, Lower Abbey St., Dublin 1, Ireland

The way that people communicate, consume media and seek and receive information is changing. Forty per cent of the world's population now has an internet connection, the average global social media penetration is 39 % and 1·5 billion people have internet access via mobile phone. This large-scale move in population use of digital, social and mobile media presents an unprecedented opportunity to connect with individuals on issues concerning health. The present paper aims to investigate these opportunities in relation to dietary behaviour change. Several aspects of the digital environment could support behaviour change efforts, including reach, engagement, research, segmentation, accessibility and potential to build credibility, trust, collaboration and advocacy. There are opportunities to influence behaviour online using similar techniques to traditional health promotion programmes; to positively affect health-related knowledge, skills and self-efficacy. The abundance of data on citizens' digital behaviours, whether through search behaviour, global positioning system tracking, or via demographics and interests captured through social media profiles, offer exciting opportunities for effectively targeting relevant health messages. The digital environment presents great possibilities but also great challenges. Digital communication is uncontrolled, multi-way and co-created and concerns remain in relation to inequalities, privacy, misinformation and lack of evaluation. Although web-based, social-media-based and mobile-based studies tend to show positive results for dietary behaviour change, methodologies have yet to be developed that go beyond basic evaluation criteria and move towards true measures of behaviour change. Novel approaches are necessary both in the digital promotion of behaviour change and in its measurement.

Social media: Digital communications: Behaviour change: Health communications: Mobile health

The way that people communicate with each other, consume media and seek and receive information has changed dramatically. Newspaper readership is falling[1], radio listenership fragmenting[2] and people time shift their television viewing, skipping advertising[3]. Forty per cent of the world's population now has an internet connection compared with <1 % in 1995. This number is set to reach 43 % (3 billion) by the end of 2014[4]. Average global social media penetration is 39 %, ranging from 82 % in Canada to 12 % in India[5]. One and a half-billion people have relatively fast access to the internet from their mobile phone[5]. This large-scale move in population use of digital, social and mobile media presents an unprecedented opportunity to connect with individuals on issues concerning health and behaviour change and to weave health information into the daily lives of citizens. The present paper aims to investigate this in relation to dietary behaviour change, drawing on examples from both nutrition and food safety. It includes an exploration of the scientific and grey literature and relevant websites, combined with the authors' communications industry knowledge, to sign-post future trends. Statistics on digital media use are focused on the island of Ireland.

Digital media is difficult to define, partly because it is ever changing, but in its broadest sense it is content that can be

Abbreviations: mHealth, mobile health; ROI, Republic of Ireland.

***Corresponding author**: A. F. McGloin, fax +35314480699, email amcgloin@safefood.eu

transmitted over the internet or computer/phone networks. Communication performed using digital technology can be carried out using multiple methods. Social media, known as the 'participative internet'[6], is a major aspect of digital communication and encompasses a broad set of internet-based communications, tools and technologies that expand interactivity and collaborative content sharing.

There is evidence that health information seekers are using the internet widely. In 2012, 72 % of internet users said that they looked online for health information[7], and 29 % said that they looked for information on food safety or recalls[8]. In addition, 60 % of smartphone applications downloaded in 2012 were weight and exercise related[9]. From an island of Ireland context, in Northern Ireland 26 % of people have sought health information online[10]. In this context, aspects of digital communication such as search engine optimisation and search marketing (the purchase of key search terms by advertisers) are important.

In terms of proactive communication, audiences can be reached using digital advertising, blogs, email marketing, online public relations activity and a plethora of social media platform, including Facebook, Twitter, Google+, YouTube, Instagram and Pinterest among others. Within these methods a variety of media such as text-based, image-based, video and animation can be used. Although there are production and human resource costs associated with the development of all of these types of digital content, it is cheaper than traditional marketing methods. The content is 'evergreen', meaning that it can be reused easily, which adds to its cost-effectiveness.

Characteristics of digital communications and dietary behaviour change

Several aspects of the digital environment offer opportunity to support behaviour change efforts. For the purpose of the present paper, these are divided into reach, engagement, accessibility: potential to build credibility and trust, collaboration and advocacy and research.

Reach

Reach, the potential of exposure to health communication, is an important aspect of the promotion of behaviour change campaigns. On the island of Ireland 65 % of households in the Republic of Ireland (ROI) have a broadband connection[11] and 80 % of households in Northern Ireland have access to the internet[10]. In Northern Ireland, nearly half of consumers own a smartphone[10], whereas in the ROI, in 2012, smartphone penetration was 57 %[12]. Ninety-six per cent of young people in the ROI have a smartphone with 42 % spending 2–4 h/d on their phone. Ninety per cent check their phone as soon as they wake up and 72 % as the last thing before going to sleep[13]. The consumption of information via digital channels is pervasive and for many, omnipresent. In relation to social media usage, a survey by Ipsos MRBI showed that in 2014, in the ROI 62 % of adults aged over 15 years use Facebook, 30 % Twitter, 26 % LinkedIn, 20 % Google+ with smaller but growing numbers using Pinterest and Instagram[14]. According to Ipsos MRBI, 76 % of the population belongs to a social community of some kind (AF McGloin, personal communication). In Northern Ireland, more than half (53 %) of the consumers reported using social networking sites, on par with the UK average[10].

In terms of reach, the use of digital communications for behaviour change is often questioned from an equality perspective. Central Statistics Office figures indicate that older people and those in lower socioeconomic groups are somewhat underrepresented[11] (S. Elsami, personal communication). Forty-six per cent of 60–74 year olds had used the internet in the past 3 months. In addition, 76 % of unemployed individuals had used the internet in the previous 3 months (*v.* 88 % of employed individuals). The Central Statistics Office data also show that there is a social gradient of social media usage. Eighty-eight per cent of those in the highest socioeconomic group belong to a social media community compared with 49 % in the lowest socioeconomic group, indicating a steep social gradient in social media use. This trend is also seen in the USA[15]. However, with almost half of those in the lowest socioeconomic groups participating in social media, this still represents an important communication opportunity within this target group in the ROI.

Engagement

Online content that can be timely, interesting, up-to-date, interactive and even personalised could help ensure that people will stay engaged with messages promoting dietary change. Evidence, from early health promotion research, shows that engagement is important for participant retention[16]. Engaging content has also been shown to enhance memory and knowledge retention[17–19]. Narration, or the art of storytelling, is an ancient form of communication of knowledge[20] and has been explored already as a tool for communicating food safety information[21]. Consumers are communicating online through images, infographics, video, animation and text and public health agencies must do likewise for messages to be heeded within this medium.

The interactive and transactional nature of the environment is also important[22]. Some authors have argued that interactivity is necessary to promote personal relevance and behaviour change[22,23]. Increasingly, mobile applications that promote physical activity or healthy eating are using gamification techniques to engage users. This is essentially the discipline of using video game mechanics to incentivise an audience and encourage them to follow specific behaviours[24]. Gamification uses concepts such as desire for reward, status, achievement, self-expression or respect and is usually driven by competitiveness or sometimes altruism. Increasingly social sharing has become a feature of games, applications and behaviour change programmes. Behaviour changes studies have shown the importance of social connection as a promoter of behaviour change[25].

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

Features such as these have the potential to promote empowerment in decision-making and can play a major role in supporting individuals as they seek positive behaviour change. Digital media has been shown to provide significant positive effects on empowerment (self-efficacy and mastery scales)[26].

Being accessible: the potential for building credibility and trust

Social media in particular offers organisations charged with changing dietary behaviour the opportunity to get closer to their key audiences. This can even be done in 'real-time' with the advent of 'Tweet-ups', 'Tweet chats' and Google+ 'hangouts'. Aspects such as speed of response, particularly in emergency situations, allow promoters of behaviour change to simply provide good customer service. Since online communication is multi-way, there is the additional potential that citizens will pass on the information to friends and family. The endorsement of these trusted individuals, adds to the credibility of the organisation and of the message. These individuals are the 'non-traditional' digital partners.

Slovic[27] identified four factors that have been observed in establishing trust. These include caring and empathy, dedication and commitment, competence and expertise, and honesty and openness. Social media provides a path for organisations to demonstrate these characteristics through the provision of consistent, timely, relevant and useful information. Since interactions online are often openly available, transparency is a common feature.

Collaboration/stakeholder engagement and advocacy

Features such as being able to share information, follow organisations and monitor online conversation not only allow organisations to communicate with the public, but also with stakeholders. Through digital platforms public health agencies can identify and engage with like-minded organisations to help expand consumer reach, amplify dissemination of key messages, and act as important advocates for each other and for behaviour change. The ease with which such collaboration can take place is novel and the formation of symbiotic relationships is potentially powerful[20]. To our knowledge this aspect of digital communication has yet to be measured.

Research potential

The online environment offers important opportunities to monitor public opinion on a variety of issues. There is tremendous potential to better understand target audiences by simply 'listening' to online conversations. Published examples include attitudes to obesity among chat board users and studies of major food safety outbreaks[28–30]. Dr Brun *et al.* showed stigmatisation in relation to obesity was pervasive and provided valuable insight on the social and psychological consequences of stigma[28]. The *Escherichia coli* o102:h4 outbreak in Germany that was responsible for over 4000 illnesses and fifty deaths generated 450 000 tweets posted by 54 381 users[31]. The Food Standards Agency in the UK now uses Twitter to try to predict outbreaks of norovirus by monitoring increases in volume of key words on social media channels[32]. Public health agencies can use this method to monitor public reaction to health promotion campaigns and can adjust campaign material in real-time to improve effectiveness.

Audience segmentation is a central tenet of campaigns to change dietary behaviour. Subgroups are targeted according to demographic, geographic, physical/personal history, psychographic or behavioural characteristics. The greater the understanding a communicator has of the target market, the more likely the message will be relevant, resonate with the target audience and promote behaviour change. Owing to the level of data available within the digital environment, and the lower cost in acquiring that data, segmentation of messaging provides the opportunity for tailoring messaging and increasing effectiveness. A meta-analysis of eighty-eight interventions that used computer tailoring to address smoking, diet, mammogram and physical activity found it to be consistently successful[33].

Data to support segmentation can be collected in a variety of ways. Individuals who register for behaviour change programmes or mobile applications may opt to provide a wealth of personalised information. Websites offering display advertising provide important sociodemographic user data to advertisers. Social channels are becoming more and more sophisticated in how audiences can be targeted. Facebook users can be targeted by location, gender, interests and device-type. Twitter provides similar targeting opportunities, but in addition account holders can be targeted by key words. For example, if a user is conversing around a dietary issue such as weight loss, an advertiser can serve that individual relevant health messaging or links to resources on weight loss. Different messaging and resources can be provided for different audiences, even on the same topic. Some harder to reach audiences, such as young men, could be targeted more easily in this way.

Digital media and behaviour change techniques

To examine which behaviour change techniques could be used to promote behaviour change in the digital environment the taxonomy of behaviour change techniques developed by Michie *et al.* was used[34]. Three UK study centres collaborated in applying an existing taxonomy to two systematic reviews of interventions to increase physical activity and healthy eating. The twenty-six behaviour change techniques were revised upward to include forty behaviour change methods. Table 1 shows how each of these behaviour change techniques could potentially be executed in a digital environment using methods, including digital advertising, provision of web content, social media, video conferencing, the use of mobile applications and gaming. All are considered feasible given the extensive reach, interactive nature and versatility of the digital environment. Many are already being used in digital-based interventions[35–37].

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

Table 1. Taxonomy of behaviour change techniques adapted from Michie *et al*. (2011) and potential for digital application[34]

Behavioural change techniques	Application
Provide information on the consequences of behaviour in general	WC, DA, SM, MA
Provide information on consequences of behaviour to the individual	WC, DA, SM, MA
Provide information about others approval	SM
Provide normative information about others' behaviour	WC, SM, MA
Goal setting (behaviour)	WC, SM, MA
Goal setting (outcome)	WC, SM, MA
Action planning	WC, SM, MA
Barrier identification/problem solving	WC, SM, MA
Set graded tasks	WC, SM, MA
Prompt review of behavioural goals	WC, SM, MA
Prompt review of outcome goals	WC, SM, MA
Prompt rewards contingent on effort or progress towards behaviour	WC, SM, MA
Provide rewards contingent on successful behaviour	WC, SM, MA, G
Shaping	WC, SM, MA
Prompting generalisation of a target behaviour	WC, SM, MA
Prompt self-monitoring of behaviour	WC, SM, MA
Prompt self-monitoring of behavioural outcome	WC, SM, MA
Prompting focus on past success	WC, SM, MA
Provide feedback on performance	WC, SM, MA
Provide information on where and when to perform the behaviour	WC, SM, MA
Provide instruction on how to perform the behaviour	WC, SM, MA
Model/demonstrate the behaviour	WC, SM, MA
Teach to use prompt/cues	WC, SM, MA
Environmental restructuring	WC, SM, MA
Agree behavioural contract	VC
Prompt practice	WC, SM, MA
Use of follow-up prompts	WC, SM, MA, VC
Facilitate social comparison	WC, SM, MA
Plan social support/social change	WC, SM, MA
Prompt identification as role model/ position advocate	WC, SM, MA
Prompt anticipated regret	WC, SM, MA
Fear arousal	WC, SM, MA, DA
Prompt self-talk	WC, SM, MA
Prompt use of imagery	WC, SM, MA
Relapse prevention/coping planning	WC, SM, MA
Stress management/emotional control training	WC, SM, MA
Motivational interviewing	VC
Time management	WC, SM, MA
General communication skills training	VC, SM (video, audio)
Stimulate anticipation of future rewards	WC, SM, MA

WC, website content; SM, social media; DA, digital advertising; MA, mobile application; G, gaming, VC, Video conference, e.g. Skype, Google+ hangout.

From a theoretical perspective, a number of behaviour change theories could inform efforts to change dietary behaviour online[23,35]. Social cognitive theory has perhaps the most potential in this domain given that it centres on the idea that behaviour is influenced by interactions with others and with the environment[38]. When individuals lack the confidence to make changes to their behaviour (low self-efficacy) they are less likely to engage in those behaviours. Addressing this step-by-step through role modelling, demonstration of behaviours, timely prompts and a variety of other techniques noted by Michie *et al.*[34], could promote increased knowledge and skills, self-efficacy and ultimately, behaviour change.

Digital media: application to food and health interventions

As with any other intervention type, digital media strategies to promote public health should be based on evidence that the approach will lead to behaviour change. Encouragingly, a limited but a growing body of research is beginning to make this possible, with positive results linked to theoretical frameworks[35]. Web-based, Mobile and social media interventions are explored below.

Web-based interventions

Web-based interventions can be defined as primarily self-guided intervention programmes, delivered through a website, aiming to create positive change and/or improve/enhance knowledge, awareness and understanding[39]. These interventions can typically include real-time support, goal-setting tools, alarms, reminders, BMI calculators, food and exercise tracking and a platform for sharing ideas with friends/peers. Web-based interventions offer potential solutions to challenges posed by face-to-face interventions because of their low cost, high reach, anonymity, adaptability and scale-ability[40].

A number of reviews and meta-analyses have examined the success and effectiveness of web-based interventions in relation to health behaviour change and have revealed mixed findings. In the present paper, only food behaviour/weight loss-related interventions are explored. A Cochrane meta-analysis of weight loss/maintenance trials by Weiland *et al.*[41] revealed that web-based interventions resulted in greater weight loss when compared with control conditions but significantly less weight loss compared with face-to-face interventions. This is similar to findings from four other meta-analyses[41–44]. Reed *et al.*[42] conducted a meta-analysis of eleven randomised controlled trials and reported additional weight loss when web-based interventions were used to supplement face-to-face interventions; however, substituting face-to-face interventions with web-based interventions resulted in significantly less weight loss. Other reviews of web-based interventions have demonstrated greater weight loss/maintenance with increased number of log-ins, self-monitoring occasions, chatroom attendances and web-posts[45,46]. However, it is important to note that some reviews have concluded that a meta-analysis could not reliably detect the effectiveness of web-based interventions due to the heterogeneity of designs and the small number of comparable studies[45–47].

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

Surprisingly, only a few studies have looked at the cost effectiveness of web-based interventions. Krukowski *et al.*[48] conducted a 6-month cost-effectiveness evaluation comparing in-person and web-only weight loss interventions and reported that while in-person interventions resulted in more weight loss (−8·0 (SD 6·1) kg *v.* −5·5 (SD 5·6) kg), incremental cost-effectiveness ratio was significantly better for web-only interventions.

Mobile health

Mobile health (mHealth) involves disseminating public health and medical information through mobile computing and communication technologies such as mobile phones, personal digital assistants, tablets and portable media players[49]. mHealth provides a convenient and personal approach to health education and communication as well as the ability to share and monitor health conditions through text messages and mobile applications[50]. In addition to text-messages, mHealth research in data-tracking devices is growing. Weight management mHealth applications have become increasingly popular over the past few years. According to Kasbo *et al.* in 2012, 60 % of smartphone applications downloaded were weight and exercise related[9]. While none of the reviews identified examined mHealth applications on their own, two systematic reviews investigated the use of mobile phone applications among other mobile technology features[51,52]. Both reviews cautiously concluded that overall, mobile phone interventions had small but positive effects on weight loss behaviour change. It is important to note that the interventions included in these reviews were very heterogeneous in design, outcomes and measures (patient satisfaction *v.* weight loss) and results. Shaw *et al.*[36] reviewed fourteen SMS-only interventions for obesity and found that eleven studies demonstrated statistically significant beneficial effects on weight, diet and exercise, whereas three studies did not show an effect on the above variables. One study that aimed to assess the effect of varying delivery mechanism of a weight-loss intervention conducted a three- armed parallel group trial and compared smartphone application, website and paper diary interventions in overweight and obese participants[53]. The authors found significantly higher weight loss, patient adherence, satisfaction and acceptability in the smartphone application group than web or paper-based interventions. In addition, drop-out rates were lowest among the smartphone application users.

When interpreting the findings of mHealth reviews, it is important to note some unique limitations of these studies, mainly the numerous applications available, the heterogeneity of their components and the frequent updates in application design and mobile phone devices that make it more difficult to conduct clinical trials of their effectiveness[9,50]. Another significant challenge for the implementation of these interventions is that while consumers are already using mobile applications to access health information, many clinicians and providers are not yet familiar with the countless possibilities of mHealth and how to incorporate it into practice.

Social media

Evidence about social media's impact on health knowledge, behaviour and outcomes show these tools to be effective in meeting individual and population health needs[20,35,54]. Most research addresses specific interventions and approaches, which vary widely in focus, target population, theoretical foundations, and mode of delivery, functionality and usability which makes it difficult to find out what works and how, and it complicates efforts to compare approaches.

A meta-analysis of interactive digital health communication applications by Murray *et al.*[55] showed that these applications improved users' knowledge, social supports, health behaviours and clinical outcomes. More recently, Napolitano *et al.*[56] demonstrated the potential of an innovative weight loss intervention where participants were randomly assigned to either a Facebook, Facebook plus personalised text messaging and feedback, or a control group. Results showed that 8 weeks post-treatment, the Facebook plus group had significantly greater weight loss (−2·4 (SD 2·5) kg) than Facebook (−0·63 (SD 2·4) kg) and control (−0·24 (SD 2·6) kg). Woolley and Peterson[57] reported that increases in physical activity of the participants were linked to their participation on the study Facebook page designed to motivate healthy attitudes and behaviours. Similarly, Rote[58] conducted an 8-week randomised pre-post walking intervention of information resources coupled with a dedicated Facebook group and found that the Facebook group participants significantly increased their steps per d over those who received the information resources only. In another study, Mychasiuk and Benzies[59] demonstrated that Facebook can provide effective means of improving participant retention in a longitudinal intervention and reduce attrition rates significantly.

Social media can provide a channel for sharing personalised information, for social support and can facilitate a sense of connectedness among individuals. Tailored messaging, repurposing and applying multiple complementary delivery modes to reinforce key themes, can encourage users to engage with web-based applications as well as with other users and are among the most promising strategies[35]. Use of communicative functions, especially access to an advisor to request advice also tends to be effective in supporting behaviour change[60]. However, one of the challenges of social media behaviour change interventions is measuring meaningful engagement, i.e. actually engaging with content as intended. The lack of evidence guiding public health enterprises is also a major challenge, but in part results from the difficulty that exists in evaluating such complex campaigns that often use different and multiple aspects of social media. Many researchers adapt established, proven approaches used in traditional health promotion efforts[61,62]. Selecting and applying appropriate metrics for evaluation present a challenge as most forms of social media are not designed with evaluation and assessment in mind, challenging evaluators to use basic analytics generated by the sites themselves.

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

Next steps for digital interventions

Web-based, mHealth and social media approaches have shown promising results when used in behaviour change interventions but currently the majority of the literature mainly supports their use in conjunction with traditional intervention methods. This hesitation may partly be due to the lack of consensus on features common to successful strategies, stemming from the wide variety of approaches, methods and outcomes addressed in various interventions. More emphasis is needed on the use of validated theoretical frameworks in the design and evaluation of digital interventions and development of evaluation metrics to guide health promotion initiatives. In addition, efforts should be made to facilitate health promotion and healthcare providers' knowledge and trust in order to achieve successful implementation of these innovative behavioural interventions.

Future trends in digital communications

A paper published in early 2014 identified ten key future trends in digital marketing[63]. These included buzz monitoring (social media monitoring) and social research, bringing the health care provider and health consumer closer, expanded traditional information dissemination models, non-traditional digital partners, social customer relations management (targeting), electronic health (e-health) and the release of personal health data, convergence of mobile and social for health, a changing role of the digital communicator, the advent of pure digital media campaigns and 'big data' i.e. a hyper abundance of data. In the time between the publication of Burke-Garcia and Scally's paper and the present paper those future trends have largely become current and most have already been discussed earlier.

Big data deserves further discussion and offers huge potential for understanding and better targeting key audiences. Currently, much discussion of big data is rooted in the potential for cost efficiencies within health care systems[64]. The focus is on health data, captured in electronic health records and other datasets, plus deep genotypic and phenotypic data, for example from genome sequencing. This approach has the potential to deliver great health benefits as well as cost savings. Digital giants such as Google are already investing in health-related big data for example in their X Baseline study that includes genetic and molecular information[65]. From a health perspective, behavioural and attitudinal data are rarely mentioned. Burke Garcia and Scally called for monitoring data to be overlaid with other research to bring a deeper understanding to the development of communications efforts[63]. There is a certainly a need for more rigorous and consistent measurement when it comes to digital media. Those promoting behaviour change need to become better at interrogating this data and understanding how to use the results. Better understanding of the needs of consumers could help inform the development and delivery of services and campaigns.

To Burke-Garcia and Scally's ten future trends there are others worth adding. Gamification has already been mentioned. These techniques are widely used by organisations as diverse as the US army, airlines, retailers and fast food companies and promote loyalty and retention[24]. Many mobile applications are already using features such as leader boards, rewards for achievements and incentives for further achievement, along with a facility to share achievements socially. Recent research from Vodafone shows that 62 % of children aged between 4 and 11 years are now using internet devices such as smartphones and tablets[66]. According to the Health Behaviour of School Children Study 27·2 % of boys and 8·4 % of girls spend over 2 h/d using a computer or games console[67]. Future generations will be extremely familiar with this approach and potentially motivated by it.

Equally, commercial companies are using a number of novel advertising methods that could easily be applied to dietary behaviour change. These include behavioural marketing, geo-marketing and adaptive marketing. Behavioural marketing is the potential to target an individual with key messages based on past online behaviour. For example, if a person were to conduct an online search for weight loss information, they could then be served a digital advertisement for a weight loss service. Geo-marketing is the potential to target marketing messages to an individual, based on their current location. This technology could enable real-time influence on decision-making around food via mobile technology and geographical information systems. Adaptive marketing is the ability to change; in real-time, elements of a behaviour change campaign based on consumer response via internet search or online comment, and could include geographical elements to ensure the campaign was delivered where there was most interest, or most need. At the current pace of change by the time the present paper is published it's likely that these future trends will be commonplace.

Challenges and barriers

Although the potentialities offered by digital health communication are vast, and in many cases still to be discovered, various challenges remain. A major challenge identified by many in relation to digital health communication relates to inequalities in access and usability[68,69]. The digital divide is a priority in relation to age, socioeconomic status and geographic area[70–73]. In an island of Ireland context, this is certainly an issue but the level of access and participation is still relatively high in all socioeconomic groups and therefore digital methods cannot be excluded from efforts to reach these population groups. Equally, global trends showing increase in internet access, social media usage and smart phone ownership indicate that this situation is changing.

Protecting citizen's privacy is another challenge-facing digital health communicators. The use of technology, which allows individuals to take pictures, record audio and video, store clinical and laboratory data, radiological

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

images and diagnostic reports and access to electronic health records, can become dangerous for the maintenance of confidentiality of data if devices are lost or compromised[74]. The public is positively disposed to the use of their health data to benefit patients but governance and security issues must continue to be taken seriously[75]. In addition, ethical issues remain around the use of publicly available personal information in research[76].

With digital discussions, misinformation and false assertions may be easily disseminated via social media and be widely believed[77]. In addition, such discussions may be more susceptive to social amplification of risk, in which risks assessed by technical experts as relatively minor, elicit strong public concerns that result in substantial impacts on society and economy[78]. One study examined accuracy of search results for five common paediatric questions and showed that it was highly variable. The authors found that 39 % of the 500 sites searched gave correct information. Governmental sites gave uniformly accurate advice. News sites gave correct advice in 55 % of cases. No sponsored sites were encountered that gave the correct advice[79]. In terms of the public's ability to assess quality of information Sillence *et al.*[80] showed that women seeking information on hormone replacement therapy could reject general websites as source of information but sometimes also rejected good quality information due to poor design. Therefore, the source and presentation of information is important as well as accuracy.

The ability to spread information rapidly online is a risk as well as a benefit. Reports to date suggest that many public health organisations, when present on social media, tend to use one-way messaging in the broadcast manner that is suitable for traditional media, but ignore the engagement element that is central to social media[81]. In contrast, Post *et al.*[82] demonstrate the dramatic impact of interactive communication on social media in relation to health behaviour outcomes. While a democratic environment can empower individuals to engage and change behaviour, the user-generated content and interactivity that are hallmarks of the digital environment mean that public health bodies must enter into an uncontrolled situation to truly participate in digital communications. Reputations can be quickly made and destroyed, so reluctance is understandable. This can be mitigated through the development and implementation of comprehensive policies and processes and by employing adaptive communicators, with both dietary and technical knowledge, to engage the public.

Perhaps most fundamental for effective development of digital communication for behaviour change is the lack of comprehensive evaluation to date[63]. According to Bert *et al.*[74], the development of applications for disease prevention and health promotion on digital platforms to date have been totally disconnected from the logic of monitoring and control of content both in terms of scientific validity and user understanding. Most intervention studies are classic, controlled experiments. Measurements tend to include website visits, 'clicks', and social engagements such as 'likes', 'follows', 'comments' and 'shares'. Few have truly measured behaviour change and this remains a central dilemma. The development of effective, measurable digital communication for behaviour change currently represents the great uncontrolled experiment and approaches to its measurement present an enormous challenge.

Conclusions

As early as 1998, Cassell *et al.*[23] dubbed the internet 'the hybrid communications channel with the persuasive properties of interpersonal communication and the reach of mass media communication'. While this remains the case, the massive and ongoing growth in the use of digital and mobile technology by citizens has heralded a new era in communication for behaviour change. Developments in social and mobile media, in particular, have meant that the online environment offers key features such as reach, accessibility and potential for engagement, research and collaboration that make it rich ground for promoting behaviour change. The digital environment presents great possibilities but great challenges in this domain.

Digital communication is by its nature uncontrolled, multi-way and co-created and concerns remain in relation to inequalities, privacy, misinformation and lack of thorough evaluation. Thus while studies tend to show positive results for behaviour change, their applicability to the real-life situation is unknown. Methodologies have yet to be developed that go beyond basic evaluation criteria and move towards true measures of behaviour change. The 'new media' is no longer new and novel approaches need to be developed both in the promotion of behaviour change and in its measurement. This will involve new thinking, new skills and particularly new collaborations involving experts in nutrition, behaviour change, and communication and information technologies.

Financial Support

None.

Conflicts of Interest

None.

Authorship

A. M. directed, researched and drafted the manuscript. S. E. researched and drafted sections of the manuscript.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S0029665114001505.

References

1. The Irish Times (2014) *Newspaper sales down across the daily and Sunday markets*. The Irish Times, February 21st, 2014. Available at http://www.irishtimes.com/business/sectors/media-and-marketing/newspaper-sales-down-across-the-daily-and-sunday-markets-1.1699140 (accessed 2 August 2014)
2. Shaw H, Picard R & Spanik HA. (2010) *Irish Boradcasting Landscape: Economic and environmental review for the Broadcasting Authority of Ireland*. http://www.bai.ie/wordpress/wp-content/uploads/20110323_StratEconAnlysRpt_vFINAL_AC.pdf
3. Nielsen Ireland (2013) *Update on Time-shiften Viewing*. http://www.agbnielsen.com/Uploads/Ireland/IrelandTSVUpdateApril2013.pdf
4. *Internet Live Stats*. Available at http://www.internetlivestats.com/internet-users (accessed 7 August 2014)
5. Kemp S (2014) *Social, Digital and Mobile Worldwide in 2014*. Available at http://wearesocial.net/blog/2014/01/social-digital-mobile-worldwide-2014 (accessed 10 August 2014)
6. Jones S & Fox S (2009) *Generations online in 2009. Pew Internet and American Life Project*. http://www.pewinternet.org/files/old-media//Files/Reports/2009/PIP_Generations_2009.pdf (accessed 10 August 2014)
7. Fox S & Duggan M. (2013) *Health Online*. Available at http://www.pewinternet.org/2013/01/15/health-online-2013 (accessed 3 August 2014)
8. Fox S. (2011) *Health Topics*. Available at http://www.pewinternet.org/2011/02/01/health-topics-2 (accessed 5 August 2014)
9. Verasoni. Mobile Health Applications: 2012 study. Available at http://verasoni.com/mobile-health-applications-2012-study (accessed 8 August 2014)
10. Ofcom (2013) *The Communications Market Report: Northern Ireland*. Available at http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr13/northern-ireland (accessed 30 May 14)
11. Central Statistics Office (2013) *Information Society Statistics – Households*. Available at http://www.cso.ie/en/releasesandpublications/er/isshh/informationsocietystatistics-households2013 (accessed 30 May 2014)
12. Google (2012) *Our Mobile Plant. Understanding the Mobile Consumer* Available at http://think.withgoogle.com/mobileplanet/en (accessed 2 July 2014)
13. O'Leary S. (2013) *The Irish Digital Consumer Report*. Available at http://shaneoleary.me/blog/index.php/the-irish-digital-report-consumer-2013 (accessed 7 June 2014)
14. Ipsos MORI (2014) *Social Networking Quarterly*. Available at http://www.ipsosmrbi.com/social-networking-may-2014.html (accessed 15 July 2014)
15. Gibbons MC, Fleisher L, Slamon RE *et al*. (2011) Exploring the potential of Web 2·0 to address health disparities. *J Health Commun* **16**, Suppl. 1, 77–89.
16. Glasgow RE, Lichtenstein E & Marcus AC (2003) Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to-effectiveness transition. *Am J Public Health* **93**, 1261–1267.
17. Erk S, Kiefer M, Grothe Jo *et al*. (2003) Emotional context modulates subsequent memory effect. *NeuroImage* **18**, 439–447.
18. Gray JR, Braver TS & Raichle ME. (2002) Integration of emotion and cognition in the lateral prefrontal cortex. *Proc Natl Acad Sci USA* **99**, 4115–4120.
19. Svirko E & Mellanby J (2008) Attitudes to e-learning, learning style and achievement in learning neuroanatomy by medical students. *Med Teach* **30**, e219–e27.
20. Chapman B, Raymond B & Powell D (2014) Potential of social media as a tool to combat foodborne illness. *Perspect Public Health* **134**, 225–230.
21. Chapman B, MacLaurin T & Powell D (2011) Food safety infosheets: design and refinement of a narrative-based training intervention. *Br Food J* **113**.
22. Noar SM & Grant Harrington N (2012) *eHealth Applications: Promising Strategies for Behaviour Change*. London: Routeledge.
23. Cassell MM, Jackson C & Cheuvront B (1998) Health communication on the Internet: an effective channel for health behavior change? *J Health Commun* **3**, 71–79.
24. Zichermann G & Linder J (2010) *Game-based Marketing: Inspire Customer Loyalty through Rewards, Challenges and Contests*, 1st ed., USA: Wiley.
25. Luke DA & Harris JK (2010) Network analysis in public health: history, methods, and applications. *Annu Rev Public Health* **28**, 69–93.
26. Samoocha D, Bruinvels DJ, Elbers NA *et al*. (2010) Effectiveness of web-based interventions on patient empowerment: a systematic review and meta-analysis. *J Med Internet Res* **12**, e23.
27. Slovic P (1999) Trust, emotion, sex, politics, and science: surveying the risk-assessment battlefield. *Risk Anal* **19**, 689–701.
28. De Brun A, McCarthy M, McKenzie K *et al*. (2014) Weight stigma and narrative resistance evident in online discussions of obesity. *Appetite* **72**, 73–81.
29. Kuttschreuter M, Rutsaert P, Hilverda F *et al*. (2014) Seeking information about food-related risks: the contribution of social media. *Food Qual Pref* **37**, 10–18.
30. Rutsaert P, Pieniak Z, Regan Á *et al*. (2014) Social media as a useful tool in food risk and benefit communication? A strategic orientation approach. *Food Policy* **46**, 84–93.
31. Diaz E & Steward AI (2012) Tracking twitter for epicemic intelligence. Web Science 2012, Proc 4th Annual ACM Web Science Conf; Illinois, USA.
32. Rutter T. (2013) *#Barf – how Twitter can Reduce the Spread of Norovirus*. Available at http://www.theguardian.com/public-leaders-network/2013/dec/11/twitter-reduce-spread-norovirus (accessed 11 August 2014)
33. Krebs P, Prochaska JO & Rossi JS (2010) A meta-analysis of computer-tailored interventions for health behavior change. *Prev Med* **51**, 214–221.
34. Michie S, Ashford S, Sniehotta FF *et al*. (2011) A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. *Psychol Health* **26**, 1479–1498.
35. Webb TL, Joseph J, Yardley L *et al*. (2010) Using the internet to promote health behaviour change: a systematic review and meta-analysis of the impact of theoretical basis, use of behaviour change techniques and mode of delivery on efficacy. *J Med Internet Res* **12** (1) e4.
36. Shaw R & Bosworth H (2012) Short message service (SMS) text messaging as an intervention medium for weight loss: a literature review. *Health Inf J* **18**, 235–250.
37. Cugelman B, Thelwall M & Dawes P (2011) Online interventions for social marketing health behaviour change campaigns: a meta-analysis of psychological architectures and adherence factors. *J Med Internet Rese* **13**.

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

38. Bandura A (1997) *Social Learning Theory* [E Cliffs, editor]. New York: Prentice-Hall.
39. Barak A, Klein B & Proudfoot JG (2009) Defining internet-supported therapeutic interventions. *Ann Behav Med* **38**, 4–17.
40. Bennett GG, Herring SJ, Puleo E *et al.* (2010) Web-based weight loss in primary care: a randomized controlled trial. *Obesity* **18**, 308–313.
41. Wieland LS, Falzon L, Sciamanna CN *et al.* (2012) Interactive computer-based interventions for weight loss or weight maintenance in overweight or obese people. *Cochrane Database Syst Rev* **8**, CD007675.
42. Reed VA, Schifferdecker KE, Rezaee ME *et al.* (2012) The effect of computers for weight loss: a systematic review and meta-analysis of randomised trials. *J Gen Int Med* **27**, 99–108.
43. Kodama S, Saito K, Tanaka S *et al.* (2012) Effect of Web-based lifestyle modification on weight control: a meta-analysis. *Int J Obes (Lond)* **36**, 675–685.
44. Grunenberg E, Lin J & Baumeister H (2013) Effectiveness of web-based psychological interventions for weight loss-a systematic review. *Die Rehabil* **52**, 182–187.
45. Neve M, Morgan PJ, Jones PR *et al.* (2010) Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. *Obes Rev* **11**, 306–321.
46. Manzoni GM, Pagnini F, Corti S *et al.* (2011) Internet-based behavioral interventions for obesity: an updated systematic review. *Clin Pract Epidemiol Ment Health* **7**, 19–28.
47. Arem H & Irwin M (2011) A review of web-based weight loss interventions in adults. *Obes Rev* **12**, e236–e243.
48. Krukowski RA, Tilford JM, Harvey-Berino J *et al.* (2012) Comparing behavioural weight loss modalities: incremental cost-effectiveness of an internet-based versus an in-person condition. *Obes* **19**, 1629–1635.
49. Free C, Phillips G, Watson L *et al.* (2013) The effectiveness of mobile health technologies to improve health care service delivery processes: a systematic review and meta analysis. *PLoS Med* **10** (1), e1001363.
50. Patrick K, Griswold WG, Raab F *et al.* (2008) Health and the mobile phone. *Am J Prev Med* **35**, 177–181.
51. Stephens J & Allen J (2013) Mobile phone interventions to increase physical activity and reduce weight: a systematic review. *J Cardiovasc Nurs* **28**, 320–329.
52. Woo J, Chen J, Ghanavati V *et al.* (2013) Effectiveness of cellular phone based interventions for weight loss in overweight and obese adults: a systematic review. *Ortho Musc Syst* **3**, 141.
53. Carter MC, Burley VJ & Cade JE (2013) Development of 'My Meal Mate' – A smartphone intervention for weight loss. *Nutr Bull* **38**, 80–84.
54. Korda H & Itani Z (2013) Harnessing social media for health promotion and behavior change. *Health Promot Pract* **14**, 15–23.
55. Murray E, Burns J, See TS *et al.* (2005) Interactive health communication applications for people with chronic disease. *Cochrane Database Syst Rev* CD004274.
56. Napolitano MA, Hayes S, Bennett GG *et al.* (2013) Using Facebook and text messaging to deliver a weight loss program to college students. *Obesity (Silver Spring)* **21**, 25–31.
57. Woolley P & Peterson M (2012) Efficacy of a health-related facebook social network site on health-seeking behaviors. *Soc Mar Q* **18**, 29–39.
58. Rote A. (2013) Examining the efficacy of a Facebook mediated intervention to increase steps per day in college freshmen: University of Wisconsin Milwaukee.
59. Mychasiuk R & Benzies K (2012) Facebook: an effective tool for participant retention in longitudinal research. *Child Care Health Dev* **38**, 753–756.
60. Fry JP & Neff RA (2009) Periodic prompts and reminders in health promotion and health behavior interventions: systematic review. *J Med Internet Res* **11**, e16.
61. Glasgow RE (2007) eHealth evaluation and dissemination research. *Am J Prev Med* **32**, Suppl. 5, S119–S26.
62. O'Grady L, Witteman H, Bender JL *et al.* (2009) Measuring the impact of a moving target: towards a dynamic framework for evaluating collaborative adaptive interactive technologies. *J Med Internet Res* **11**.
63. Burke-Garcia A & Scally G (2014) Trending now: future directions in digital media for the public health sector. *J Public Health* 26 January, 1–8.
64. Groves P, Kayyali B, Knott D *et al.* (2013) *The Big-data Revolution in US Health Care: Accelerating Value and Innovation*. Available at http://www.mckinsey.com/insights/health_systems_and_services/the_big-data_revolution_in_us_health_care (accessed 13 August 2014)
65. Barr A. (2014) *Google's new Moonshot Project: The Human Body*. Available at http://online.wsj.com/articles/google-to-collect-data-to-define-healthy-human-1406246214 (accessed 13 August 2014)
66. Vodafone. (2013) *Help is at Hand: Vodafone and Moshi Monsters team up to teach kids 'Digital Facts of Life'*, Available at http://blog.vodafone.co.uk/2013/11/18/help-hand-vodafone-moshi-monsters-team-teach-kids-digital-facts-life (accessed 11 August 2014)
67. Currie C, Zanotti C, Morgan A *et al.* (2012) Social determinants of health and well-being among young people. Health behaviour in school aged children (HBSC) study: International report from the 2009/2010 survey. Copenhagen.
68. Fesenmainer J. (2003) *Executive Summary: Measuring Outcomes of Digital Divide Investment to Community Technology Centers*. Available at http://www.communitydevelopment.uiuc.edu/PDFs/ExecutiveSummary.pdf (accessed 13 August 2014)
69. Liang TH (2014) Matrix analysis of the digital divide in eHealth services using awareness, want, and adoption gap. *J Med Internet Res* **14**, e11.
70. Liff S, Shepard A, Wajcman J *et al.* (2004) An evolving gender divide? OII Internet Issue, Brief No 2.
71. Aqili SV & Isfandyari Moghaddam A (2008) Bridging the digital divite: the role of librarians and information professionals in the third millennium. *Electron Libr* **26**, 226–237.
72. Roy S & Ghose S (2006) Internet adoption as a two-stage transition: converting internet non-users to internet users and to online buyers. *Int J Mark Res* **48**, 321–349.
73. Livingstone S & Helsper E (2010) Balancing opportunities and risks in teenagers' use of the internet: the role of online skills and internet self-efficacy. *New Media Soc* **12**, 309–329.
74. Bert F, Giacometti M, Gualano M *et al.* (2014) Smartphones and health promotion: a review of the evidence. *J Med Syst* **38**, 1–11.
75. Whitehead S (2014) *360 of Health Data: Harnessing Big Data for Better Health*. Available at http://www.abpi.org.uk/our-work/library/medical-disease/Pages/360%CB%9A-of-Health-Data-harnessing-big-data-for-better-health.aspx (accessed 14 August 2014).
76. Zimmer M (2012) *Research Ethics in the 2·0* Era: New Challenges for Researchers and IRBS. Available at http://www.slideshare.net/michaelzimmer/research-ethics-in-the-20-era-new-challenges-for-researchers-and-irbs (accessed 14 August 2014).
77. Chung IJ (2011) Social amplification of risk in the internet environment. *Risk Anal* **31**, 1883–1896.
78. Kasperson RE, Renn O, Slovic P *et al.* (1998) The social amplification of risk: a conceptual framework. *Risk Anal* **8**, 177–187.

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press

79. Scullard P, Peacock C & Davies P (2010) Googling children's health: reliability of medical advice on the internet. *Arch Dis Child* **95**, 580–582.
80. Sillence E, Briggs P, Harris PR *et al.* (2007) How do patients evaluate and make use of online health information? *Soc Sci Med* **64**, 1853–1862.
81. Neiger BL, Thackeray R, Van Wagenen SA *et al.* (2012) Use of social media in health promotion: purposes, key performance indicators, and evaluation metrics. *Health Promot Pract* **13**, 159–164.
82. Post SD, Taylor SC, Sanders AE *et al.* (2013) If you build (and moderate) it, they will come: the Smokefree Women Facebook page. *J Natl Cancer Inst Monogr* **2013**, 206–208.

https://doi.org/10.1017/S0029665114001505 Published online by Cambridge University Press